(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 August 2001 (16.08.2001)

PCT

(10) International Publication Number
WO 01/59709 A1

(51) International Patent Classification[7]: G06T 7/00

(21) International Application Number: PCT/US01/02160

(22) International Filing Date: 23 January 2001 (23.01.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/502,937 11 February 2000 (11.02.2000) US

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(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

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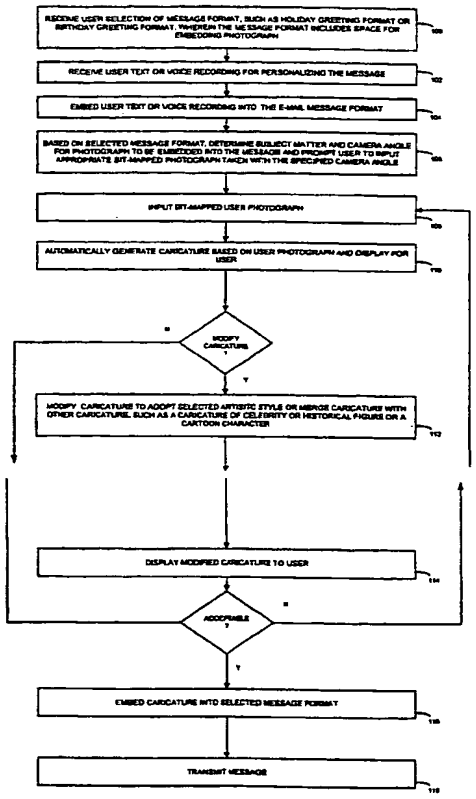
(54) Title: INTERNET-BASED METHOD AND APPARATUS FOR GENERATING CARICATURES



(57) Abstract: An Internet-based system is described for generating line art caricatures or other caricatures based upon photographs selected by a user. The caricatures may be employed to personalize computer messages, such as birthday greetings and holiday greetings (100). Alternatively, the caricatures may be employed as Avatars for use within chat rooms or multi-player computer games (100). The caricatures are created (110) by automatically locating image zones (126) within the selected photograph, then separately converting features within the zones into vector-based caricature representations (128) using conversion techniques optimized for use with each particular zone. After the separate features have been independently converted into a vector-based representation, the features are combined and then a caricature is rendered (116). Thereafter, the user may choose to modify the caricature to reflect a particular selected artistic style (142), such as a style reminiscent of popular comic book, television or motion picture cartoons. Alternatively, the user may choose to merge the caricature with pre-stored caricatures (242) corresponding to particular cartoon characters, celebrities or historical figures.

WO 01/59709 A1

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNET-BASED METHOD AND APPARATUS FOR GENERATING CARICATURES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention generally relates to e-commerce web sites and in particular to an e-commerce web site for automatically converting an input image, such as a user photograph, into a line art caricature or other caricature.

2. Description of Related Art

Millions of e-mail messages or other computer mail messages are transmitted via the Internet every day. As the speed and bandwidth of the Internet has increased, and as the speed of modems used by individual users has increased, it is becoming increasingly feasible to send a photograph of the sender along with the computer message to thereby personalize the message. This is particularly desirable for holiday greetings, birthday greetings and the like. Likewise, it has become feasible for participants of chat rooms, multi-user computer games, and the like, to employ visual Avatars for use in representing themselves within the chat rooms or computer games. Accordingly, some Internet users now scan a photograph of themselves into their computer to create a bit-mapped image for forwarding along with computer messages or for use as an Avatar. Often, however, users are unsatisfied with the bit-mapped photographic image, and would prefer to modify the image as needed to generate an image with which they are more comfortable. In other cases, users might want to provide an amusing caricature of themselves, rather than a simple bit-mapped photograph. To this end, a user may wish to convert his or her picture into a cartoon caricature having a particular artistic style, perhaps one reminiscent of popular comic book, television, or motion picture animation styles. Also, bit-mapped images are typically fairly large images requiring considerable resources to upload and download via the Internet. Accordingly, many users might prefer to convert their bit-mapped photograph into a more compact image format, such as vector-based format, before sending via the Internet.

Accordingly, it would be desirable to provide an Internet web site for permitting users to easily convert bit-mapped photographs into vector-based caricature images, to selectively enhance or modify aspects of the caricature images, or to convert the caricature into a cartoon having a selected artistic style. Heretofore, as far as the inventors are aware, no Internet web sites

are available providing this combination of features. Moreover, an attempt to create such a web site using conventional automated image processing techniques may not be feasible. Conventional techniques for converting a bit-mapped photograph into a vector-based image typically process the entire input photograph to extract the vectors, often resulting in an output image that emphasizes shadows or other artifacts in the photograph unrelated to the actual features of the object of the photograph, such as the eyes, nose and mouth of a person pictured in a photograph. Hence, such conventional techniques may not be suitable for use in a web site for converting an input photograph into a caricature image. Conventional techniques for enhancing or modifying aspects of a photograph also typically process the entire input image resulting in similar problems. For example, one technique that may be employed for modifying aspects of an image is to morph the image together with another image. However, typical morphing techniques are applied uniformly throughout the images, resulting in a final image wherein distinctive facial features, such as those of the eyes, nose, and mouth, are often considerably distorted. In this regard, portions of the eyes of one image may be morphed with portions of the nose of another image resulting in a highly distorted final image. These problems are even more significant when morphing a photograph with a cartoon character, typically resulting in a highly comical but rather unsatisfactory final image. Moreover, conventional automated morphing techniques typically require considerable processing power and hence may be relatively slow or expensive to perform, particularly for use within a heavily accessed Internet site. Conventional morphing techniques can be fairly complex and many Internet users may not wish to learn techniques needed to control a potentially complex morphing process. Hence, such conventional techniques may not be suitable for use in a web site to selectively enhance or modify aspects of caricature images or to convert caricatures into cartoons. Also, conventional morphing techniques typically require that one input image be morphed with another image and hence may not be suitable for generating a cartoon caricature merely having a certain selected artistic style.

Furthermore, as the speed and bandwidth of the Internet increases, it becomes increasingly feasible to employ animation in connection with computer messages, chat room Avatars, and the like. Problems associated with conventional techniques for generating and processing photographs, Avatars, and the like are even more significant in circumstances wherein the images need to be animated.

Accordingly, it is desirable to provide an Internet web site for permitting users to easily convert bit-mapped photographs or other images into vector-based caricature images, to

selectively enhance or modify aspects of the caricature images, or to convert the caricatures into cartoon caricatures having a selected artistic style. It is also desirable to provide improved image processing techniques for use with such a web site. In particular, it would be desirable to provide a technique for easily and efficiently converting a bit-mapped image into a caricature image, which retains distinctive facial features of the bit-mapped image. It also would be desirable to provide a technique for efficiently converting the caricature into a cartoon which does not result in a highly distorted final image and which permits control of the style of animation. It also would be desirable to provide a technique for efficiently combining a pair of caricature images together in a manner that does not result in a highly distorted final image. It is to these ends that aspects of the present invention are primarily directed.

SUMMARY OF THE INVENTION

In accordance with a first aspect of the invention, an interactive network web site is provided that includes an image selection unit for receiving a user selection of an image and a caricature generation unit for automatically generating a caricature image representative of the selected image. The term caricature as used herein is not intended to imply that the caricature is necessarily an exaggerated or distorted representation of the selected image. For example, the caricature may be a realistic line art representation of the selected image.

In an exemplary embodiment of the first aspect of the invention, the interactive network web site is an Internet site. The selected image is a bit-mapped photograph either received via the Internet or selected from a database of stored images. The selected image is converted to a vector-based caricature for embedding within a computer message, such as a holiday or birthday greeting. The caricature may also be used as an Avatar within chat rooms or multi-player computer games or for other purposes. By using a caricature, rather than a simple bit-mapped photograph, the image of the user is therefore far more distinctive than one merely containing an ordinary photograph. The use of a caricature is particularly advantageous for those who do not wish to use a photograph of themselves, perhaps because the photograph is unflattering or because the user is otherwise uncomfortable with transmitting a photograph, unmodified, via the Internet. Also, a vector-based image typically requires fewer bytes than a bit-mapped photograph and hence can be easier to transmit, store and display via the Internet.

Also, in the exemplary embodiment of the first aspect of the invention, the caricature, once generated, can be modified to adopt a distinctive artistic style drawn from pre-stored artistic styles, such as styles based on popular television or motion picture cartoon characters or original

artistic styles, or can be merged with another caricature. In this manner, the user can generate a more amusing and memorable caricature for use via the Internet.

In accordance with a second aspect of the invention, a method is provided for use by a computing system to convert an input image into a computer representation of a caricature image. Initially, a set of image zones is automatically located within the input image. Portions of the input image lying within each image zone are separately converted into individual respective line representations. The individual respective caricature representations are then combined to yield a combine caricature representation.

In an exemplary embodiment of the second aspect of the invention, the input image is a bit-mapped photograph of a face. The set of image zones automatically located within the input image are facial image zones such as the left eye, the right eye, the nose and the mouth. By first locating image zones within the bit-mapped photograph, then separately converting portions of the input image lying within the image zones into caricature representations, the resulting combined caricature representation can more effectively retain the distinctive features of the photograph than is achieved using conversion techniques of the type which uniformly process the entire input image. Hence, a more satisfactory caricature image may be generated. Preferably, separate conversion algorithms are used within the separate image zones, each specifically adapted for processing the distinctive features of the respective image zone. Also, preferably, the resulting caricature representation is defined by geometrical nodes associated with each image zone, which collectively define the features within the image zone. Hence, the resulting image representation is highly compact and can be easily processed, perhaps to generate multiple caricatures each adopting a different distinctive artistic style.

In accordance with a third aspect of the invention, a method is provided for use by a computing system to render a caricature image adopting a selected artistic style. In accordance with the method, a caricature image representation is input and an artistic style is selected. Then, an image is rendered based on the caricature image representation while applying the selected artistic style.

In an exemplary embodiment of the third aspect of the invention, the caricature image representation is a vector-based caricature representation generated from a user image or other image. The selected artistic style is representative of popular television or motion picture cartoon characters or an original artistic style. The image rendered by the computing system based on the vector-based caricature and the selected artistic style is a cartoon caricature. The artistic style defines general features for use in generating the cartoon caricature, such as whether the eyes,

nose and mouth of the caricature should be large or small. The artistic style also defines colors or line drawing textures for use in rendering the caricature, such as whether lines should be bold and curved or thin, rough and angular. By rendering a caricature so as to adopt a selected artistic style, a memorable line caricature is thereby created for use via the Internet or for other applications.

In accordance with a fourth aspect of the invention, a method is provided for use by a computing system to combine computer representations of first and second images. Initially, a set of corresponding image zones within the first and second images are located. The image zones of the first image are separately modified based on characteristics of corresponding image zones of the second image to yield separately modified image zones. Then, the separately modified image zones are combined to yield a computer representation of a modified image.

System embodiments are also provided. Other objects, features and advantages of the invention will be apparent from the descriptions provided below in combination with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates an Internet-based method for generating a computer message having a caricature incorporated therein.

FIG. 2 illustrates a method for generating a caricature based on an input bit-mapped photograph for use within the method of **FIG. 1**.

FIG. 3 illustrates a method of modifying the caricature generated by the method of **FIG. 2** based on a pre-stored artistic style also for use within the Internet-based method of **FIG. 1**.

FIG. 4 graphically illustrates the generation of a caricature based on a bit-mapped photograph performed by the method of **FIG. 2** and further graphically illustrates modification of the caricature based on an artistic style as performed by the method of **FIG. 3**.

FIG. 5 illustrates a method of merging a caricature generated by the method of **FIG. 2** with another caricature also for use within the Internet-based method of **FIG. 1**.

FIG. 6 illustrates a system for performing the methods of **FIGS. 1 - 5**.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

With reference to the figures, preferred and exemplary embodiments of the invention will now be described. The techniques of the invention will primarily be described with reference to an Internet-based method for generating a computer message having a line art caricature or other caricature embedded therein. The caricature is generated by converting a photograph into a caricature image. Then, depending upon the programming of the system and the commands entered by a user, the caricature may be modified so as to adopt a selected artistic style or merged with another caricature. However, principles of the invention are applicable for use in other systems and to achieve other ends. The techniques are not limited for use with interactive web sites but may be employed in connection with stand-alone computers or computer kiosks. The techniques described herein for converting a photograph into a caricature need not be performed in conjunction with generating a computer message. The techniques for modifying a caricature so as to adopt a selected artistic style need not be performed in conjunction with images derived from original bit-mapped photographs. Accordingly, it should be understood that the examples described herein are provided for illustrative purposes only and are not to be taken as limiting the scope of the invention as set forth in the accompanying claims.

Initially, the Internet-based method for generating a computer message having a caricature embedded therein will be described with reference to **FIG. 1**. Techniques for converting a bit-mapped photograph into a caricature will be described with reference to **FIGS. 2 and 4**. Techniques for modifying the caricature to adopt a selected artistic style will be described with reference to **FIG. 3 and 4**. Techniques for merging the caricature with another caricature will be described with reference to **FIG. 5**. Then a system performing the techniques of **FIGS. 1 - 5** will briefly be summarized with reference to **FIG. 6**.

The method of **FIG. 1** is performed by an interactive network web site computer system connected to the Internet and accessible as an Internet web site by Internet users via a web browser. Initially, at step **100**, the user selects a general format for the computer message from a group of predetermined message formats stored within the computer system. Each computer message format includes space for a picture, such as a picture of a person, couple, house, pet, boat, car, skyline, horizon, landscape etc. Thousands of individual computer formats are preferably provided, categorized according to the general purpose of the computer message. Examples of general categories include holiday greetings, birthday greetings, reminders, anniversary greetings, vacation greetings, and wedding invitations. Within each general category,

numerous specific formats are provided corresponding to the category. For example, for holidays, separate formats are provided for Christmas, Easter, Chanukah, Fourth of July, etc. For birthday greetings, specific formats are provided for different age groups as well as for different genders. Once the user has selected a format, then, at step **102**, the user inputs or selects specific text or sound recordings for incorporation into the format. For example, the user may modify a prewritten birthday greeting to personalize the greeting or may provide entirely new text to replace prewritten greetings. The user may recite a message into a microphone of the user's computer, which digitizes the voice, sends it to the web site computer for incorporation within the message. At step **104**, the computer system embeds the text or voice recording, if any, provided by the user into the computer message format.

As noted, each message format includes space for a picture. At step **106**, the system determines the subject mater of picture and the particular camera angle required for the picture to be inserted into the message, based upon the pre-stored format of the message. For example, for a message format with space for a facial photograph, the system determines whether a front view, side view, left angle, right etc. is required, then prompts the user to input a bit-mapped photograph having the prescribed camera angle. The user inputs the photograph at step **108** by transmitting the image via the Internet from a computer of the user to the web site computer system. The bit-mapped photograph is initially generated using a digital camera or other digital input device or by scanning a photograph using a digital scanner or by uploading or downloading an image from a computer database. For example, if the user's computer has a digital camera mounted thereto, the system may prompt the user to take a digital photograph using the digital camera for immediate transmission via the Internet. Alternatively, the user selects from among photographs previously input into the system and stored therein or from among previously converted vector-based images. To this end, each individual user may initially download numerous photographs into the computer system for storage therein to provide a library of images. The library may include various pictures taken at different angles of the user, his or her friends or family, pets, houses, boats etc. In any case, once the user has input a bit-mapped photograph or selected from among pre-stored photographs then, at step **110**, the system generates a caricature of the photograph and displays the caricature for the user by transmitting the caricature via the Internet to the user's computer. The caricature is a vector-based image. Geometric nodes defining the vectors are stored by the system. Depending upon the programming of the computer system and upon any commands entered by the user, the

generation of the caricature is performed entirely automatically or is performed in conjunction with specific user commands. At step **112**, subject to the control of the user, the caricature may be modified to adopt the characteristics of a selected artistic style to yield a cartoon caricature or may be merged with another caricature. At step **114**, the user has the opportunity to review the caricature that has been generated and to accept or refuse the caricature. Assuming that the user is satisfied with the caricature, then the system embeds the caricature within the selected computer message format, at step **116**, and then sends the computer message at step **118**.

Thus, **FIG. 1** illustrates an Internet-based technique for embedding caricatures within computer messages, particularly within holiday greetings, birthday greetings, and the like. In this manner, the user may personalize the greeting to a much greater extent than can be achieved merely by incorporating text greetings. Moreover, by generating and sending a caricature, rather than a simple bit-mapped photograph, the message received by the recipient is likely to be far more distinctive than one merely containing a simple bit-mapped photograph. The creation of a caricature is particularly advantageous for those who do not wish to send a simple photograph, perhaps because the photograph is unflattering or because they are simply uncomfortable with transmitting their photograph via the Internet. Also, as will be more fully explained below, in generating the caricature, the user has the opportunity to adjust or modify features to enhance the visual representation as desired.

Although described with reference to a system which first converts bit-mapped images into caricatures then modifies the caricature based on a selected artistic style, the general techniques of **FIG. 1** alternatively may be performed to just create an initial caricature, or to just modify a caricature based on an artistic style, or to just merge a caricature image with another. Also, the system may be configured to convert among different types of image formats, such as from vector-based to vector-based rather than only from bitmapped to vector-based. The final caricatures or other final images need not be employed only in conjunction with computer messages, but may be employed as Avatars for use in chat rooms, multi-player computer games, and the like or may merely be printed out and not used via the Internet at all. Also, the final caricature for embedding in the message may be animated. Or the final caricature need not be embedded within a message at all. As will be described more fully below, the caricatures are internally represented as a set of geometrical nodes that facilitate animation. For the purposes of animation, the input image may be an entire sequence of images of a person, object or animal in motion, with each image converted into a caricature to achieve an animated sequence. The input

image may comprise motion capture data from which animation can be generated. Depending upon the implementation, the system may incorporate the animated caricature within a message story vignette, perhaps to show the caricature blowing out the candles of a birthday cake. Also, 3-D caricatures may be generated by, for example, processing multiple views of the same person taken from different angles. Furthermore, the computer network of **FIG. 1** need not be the Internet, but may be an Intranet or other limited computer network. Moreover, when implemented in connection with the Internet, many of the steps of the invention may be performed within the user's computer rather than within the web site server, perhaps using plug-ins or the like. Also, aspects of the method need not be implemented via a computer network at all, but instead may be implemented within a stand-alone computer or kiosk. To this end, software performing the steps of the method may be stored on CD-ROM's, floppy disks or the like for loading into user computers. Also the method may be implemented via a channel rather than a web site. As can be appreciated, numerous other modifications or applications of the general techniques of **FIG. 1** may be provided consistent with the general principles of the invention.

Techniques for converting a bit-mapped image into a vector-based caricature will now be described for an example involving a facial image with reference to **FIG. 2** in conjunction with **FIG. 4**. The steps of **FIG. 2** may be modified as needed to process other images, such as houses, cars, boats, etc. Initially, at step **120**, the system verifies the integrity of the bit-mapped image (item **121** of **FIG. 4**) input by the user. To this end, the system verifies that the exposure, contrast, focus and other image quality features are all within acceptable pre-determined ranges. If the image fails the integrity test, the user is prompted to input an alternative image or to otherwise correct the image. The system preferably incorporates various tools for altering the image, such as changing the contrast and the like, so that the user may attempt to remedy any defects in the image. Alternatively, the system may automatically perform steps directed to remedying the image defects on behalf of the user, then present the corrected image to the user for verification that the image is acceptable.

At step **122**, the system then analyzes the bit-mapped image to extract the outline of the face (item **123** of **FIG. 4**) contained within the image. This is performed by analyzing the differences between two or more adjacent pixels, such as differences in brightness, contrast, color and the like. One exemplary technique that may be employed by the system is to process the bit-

mapped image using the following filter applied to each block of nine adjacent bits:

-1	-1	-1
-1	8	-1
-1	-1	-1

The aforementioned filter operates to highlight changes in contrast within the image. Any part of the image where an absolute filtered value is higher than a predetermined threshold is defined as an "edge" of the image. Additional information regarding edge detection may be found within a chapter entitled *Noise Thresholding in Edge Images* by John Schlag, (pp. 105-106) of *Graphics Gems* edited by Andrew S, Glassner, Academic Press (1990).

Having identified the edge of the input image, the system next locates predetermined image zones such as the eyes, nose, mouth, eyebrows, forehead, hair profile, hairline, jaw line, chin, cheekbones, and ears within the image by applying a facial image zone template to the outline. (For other image types, such as houses or boats, other image zones are defined.) More specifically, within step **124**, the system inputs an image zone template (item **125** of **FIG. 4**) having predetermined image zones. In the example, of **FIG. 4**, only a few of the image zones are illustrated. At step **126**, the system adjusts the size and location of the image zone template to fit the outline of the bit-mapped image. This may be achieved by fitting an face perimeter template, such as an oval or round template, to the of the image while simultaneously adjusting the sizes and locations of internal image zones in accordance with the adjusted size and location of the oval face perimeter template. This may be performed by minimizing an average distance between points on the oval perimeter and points within the outline derived from the bit-mapped image. When fitted properly, the individual image zones of the template fit over the corresponding facial features in the bit-mapped image. In other words, the right eye zone template fits over the right eye of the image; the mouth zone template fits over the mouth of the image, and so on. To ensure proper fit, the technique employed to fit the oval perimeter to the face is preferably performed so as to be relatively unaffected by any portions of the outline that may represent beard or hair, rather than facial outline. To this end, left and right portions of the oval template are more closely fitted to left and right portions of the bit-mapped image outline as compared with the top and bottom portions of the oval perimeter and top and bottom portions of the image outline. Also, the forehead zone may be independently fitted first, with the other

facial zones thereafter fitted below the hairline. Note that the operations of step **126** are performed internally within the computer system using digitized data not requiring actual super-positioning of a graphic template over the facial image. The graphic template illustrated in **FIG. 4** is provided to symbolically illustrate the operations performed by the computer and not to imply that a graphic template is required.

Thus, the system automatically identifies the locations of pre-determined features of the input image without requiring further user input. This is a significant advantage over systems that would require the user to separately identify facial features, which may be a laborious process. However, for those users who wish to assist the computer system in identifying the facial features, the system may be programmed to display the bit-mapped image along with a graphical image zone template and permit the user to manually superimpose one above the other.

Having identified the location of the various image zones within the bit-mapped image, the system then, at step **128**, independently processes portions of the bit-mapped image lying within each respective image zone to generate a vector-based representation of features within the zone. To this end, the system analyzes the bit-mapped image lying within each respective image zone and identifies pre-determined geometric nodes therein. The nodes include specific geometrical points, tangents and the like. Within item **131** of **FIG. 4**, five exemplary nodes (A) - (E) are identified within the bit-mapped image of the right eye. As can be seen, the nodes correspond to the left and right corners of the eye, the center of the pupil, and horizontal tangents lying along the top and bottom portions of the eye. To provide a more detailed representation of the eye, a greater number of nodes may be employed. (The eyebrow of item **131** is analyzed separately from the eye; resulting in separate nodes, not specifically show in **FIG. 4**.) Also, in step **128** the bits defining the edge of the face are processed to generate a vector representation of the outline of the face.

The characteristics of particular nodes for identification within each zone within step **128** are pre-determined and are stored within the system. Hence, during step **128**, the system need only locate the position or other characteristic of each predetermined node within the image zone based on the identifying characteristics of the nodes. The nodes, once identified, are then saved by the system for use in generating a caricature. A caricature of the eye, for example, can be subsequently generated by drawing an ellipse connecting the left and right corner nodes and the upper and lower tangent nodes and by drawing a pupil having the size and location identified by the pupil node. In this manner, the original bit-mapped image is converted to a compact set of

geometrical nodes from which the caricature can be generated subsequently. An exemplary caricature is shown as item **135** of **FIG. 4**.

As noted, the conversion of the bit-mapped representation to a vector-based representation is performed separately and independently for the image zones using separate conversion techniques appropriate to the features within those zones. For example, the conversion algorithm for identifying the geometrical nodes within the right eye is optimized for identifying distinctive features of the eye, such as the left and right corners, upper and lower eyelid tangents and the size and center of the pupil. The conversion algorithm for converting the bit-mapped image corresponding to the mouth into a caricature image of the mouth is optimized for identifying features of the mouth.

For the example involving the eye, an exemplary conversion algorithm for use in locating the pupil of the eye is as follows:

$$E = \sum_{i=1}^{n} \left| (x_i - x_c)^2 + (y_i - y_c)^2 - r^2 \right|$$

Above equation is used to find the pupil by finding the best circle fitting a set of points by minimizing the integral square error (E). Values x_i and y_i represent the locations of bits corresponding to the pupil. Variable r represents the radius of the pupil and variables x_c and y_c represent the location of the center of the pupil. Variables r, x_c, and y_c are determined by minimizing E over all of bits x_i and y_i. In this manner, the size and position of the pupil is identified and the bit-mapped image of the pupil is thereby converted into a vector representation defined by solely by r and center location x_c, and y_c, which define node (e) representing the pupil. Hence, a graphic representation of the pupil thereafter may be generated merely by displaying a filled circle of radius r and center location x_c, and y_c. The same conversion algorithm may be applied for use with other round image zone features as well, such as automobile wheels within a picture of an automobile being converted into a caricature.

To approximate the outline of the eye, or any other generally elliptical feature, the following equation may be employed to first determine the semi-major and semi-minor axis of the elliptical feature:

$$\sum_{i}^{n}\left(\frac{x_i^2}{a^2}+\frac{y_i^2}{b^2}-1\right)=0$$

The semi-major (a) and semi-minor (b) axes of the ellipse are determined for a given set of n points on the average where the coordinates x_i and y_i are calculated with respect to a system of coordinates having its center at the center of the ellipse, and the axes parallel to the ellipse axes. Once the semi-major and semi-minor axes are determined, other equations may be employed to determine the location of the center of the ellipse with respect to other features of the caricature. Then, the left and right and top and bottom points on the ellipse are determine for storage as nodes (a) - (d). In this manner, the size, shape and position of an elliptical facial feature are identified and the bit-mapped image of the feature is thereby converted into a vector representation. Hence, a graphic representation of the elliptical facial feature thereafter may be generated merely by displaying an ellipse of the determined size, shape and location. For the eye, as an alternative, other conversion algorithms maybe employed for directly locating tangents (b) and (d) and corners (a) and (c) which do not require first determining the semi-major and semi-minor axes. Also, more complex conversion algorithms may be employed to generate a greater number of nodes per facial feature so as to more precisely approximate the feature.

Thus, within each image zone, one or more conversion algorithms are employed, with the particular conversion algorithms selected based on the features expected to be found in the image zone. In this manner, the overall bit-mapped image to caricature image conversion algorithm is optimized for each image zone. For an image zone expected to contain circular and elliptical features, the above conversion algorithms may be employed. For an image zone expected to contain curved lines, such an image zone covering the eyebrows, conversion algorithms adapted to locating curved lines are employed. For an image zone expected to contain square features, such image zone applied to the windows of a house, conversion algorithms adapted to locating squares are employed. Each conversion algorithm converts portions of the image into one or more geometrical nodes, which may be represented by numerical values such as object center locations, radii, lengths, tangent points, etc. The geometrical nodes are stored along with an indication of the type of node, i.e. whether the node defines a circle, a portion of an ellipse, a

straight line etc. As can be appreciated, numerous different algorithms may be employed depending upon the subject matter of the image and the particular image zone contained therein. No attempt is made herein to describe or identify the many possible conversion algorithms. Those skilled in the art can readily develop conversion algorithms adapted for particular image types and image zones. General information pertaining to the generation of a vector-based representation may be found within *Vectorization of Digital images Using Algebraic Curves*, Zhang et al., Computing and Graphics, Vol. 22, No. 1, pp. 99-101 (1998).

Following the steps of **FIG. 2**, the caricature is generated by drawing an image using all the geometric nodes identified in step **128** with all the image zones (item **135** of **FIG. 4**) corresponding to the original input image. When generating the caricature, the system preferably applies different textures to different image features. For example, when drawing the eyebrow, the system applies a predetermined rough texture. Hence, although the eyebrow may be internally represented using only a set of nodes defining a simple geometrical arc, the eyebrow drawn in the caricature is a more realistic eyebrow. In general, every feature of the image as represented by the geometrical nodes may be processed using textures when generating the caricature. When generating the caricature, the system also preferably applies different colors to the different image features. The colors may be determined by sampling corresponding portions of the input image. As one example, the pupil may be sampled to determine the color of the eye, then that color is employed when generating the pupil in the caricature. Alternatively, rather than applying colors and textures, a simple line art caricature can be generated.

The caricature is displayed to the user to verify that the character is acceptable to the user. If acceptable, the caricature may thereafter be embedded into the aforementioned computer message or perhaps employed as an Avatar for use within a chat room, multi-player computer game or the like. If the caricature is unacceptable, the user may generate a new caricature based upon a newly input photograph or, depending upon the programming of the system, may adjust various parameters used in generating the caricature in an attempt to provide a more acceptable caricature. For example, the system may provide tools to permits the user to manually control the identification of the location of the eyes, nose and mouth if it appears that the automatic determination performed by the system is not accurate. Preferably, also, the user is provided with tools for controlling the textures use in generating the caricature from the geometrical nodes so as to provide greater control over the resulting caricature. Also, the user is preferably provided with tools to permit the caricature to be modified so as to incorporate a wig, hat, etc, or if the

caricature only covers the face, to superimpose the face on a cartoon body or within a cartoon vehicle. Other tools are provided to permit the user to animate the caricature, perhaps to make the eyes blink or the mouth move. Since the caricature is internally represented by nodes, it is easy to animate the caricature by sequentially rendering the caricature while changing node locations. For example, an eye can be made to blink by alternately changing the spacing between nodes (b) and (d) of item **131** of **FIG. 4**. As another example, the mouth can be made to open and close by alternately changing the spacing between nodes define top and bottom portions of the lips. If a voice recording is provided for use with the caricature, the movement of the mouth may be synchronized with the voice to provide the illusion that the caricature is speaking the words of the voice recording.

Thus, **FIG. 2** illustrates a method for converting a bit-mapped image into a caricature. Although described primarily with reference to the conversion of the facial images, the general techniques of **FIG. 2** may be applied to converting other bit-mapped images into caricatures, such as converting the photograph of a house into a caricature of the house or converting the photograph of a person's body to a caricature. To this end, a separate set of image zones are defined, corresponding to standard features of homes. For example, an image zone corresponding to the doors and windows may be employed within a generally rectangular outline corresponding to the outline of the house.

In many cases, the user may be satisfied with the caricature generated via the steps of **FIG. 2** and will perform no further processing. In other cases, the user may wish to modify the caricature to adopt a predetermined artistic style or to merge the caricature with another caricature. To modify the caricature to adopt a selected artistic style, the steps of **FIG. 3** are performed. To merge the caricature with another, the steps of **FIG. 5** are performed. Referring first to **FIG. 3**, at step **140**, the system inputs an artistic style (represented by item **141** of **FIG. 4**) selected by the user for use in modifying the caricature. Exemplary artistic styles include styles associated with popular television programs, movies, comic books etc. The artistic styles may also be representative of animation techniques, such as cardboard cutout animation or pen and ink animation. One specific style is the Japanimation style associated with many Japanese cartoons. Each style is represented in vector form using the same types of geometric nodes as with the caricature, but sized and shaped so as to correspond with the particular artistic style. Hence, if the artistic style calls for characters with large bulbous eyes, nose and mouth, the nodes associated with the style are thereby pre-set to be wide apart (item **141** of **FIG. 4**). However,

whereas a particular caricature may be represented using a large number of nodes per image zone so as to fairly closely represent the original image, the style typically is defined using relatively few image nodes, so as to merely convey the general characteristics of cartoon characters of the artistic style rather than to correspond closely to a specific cartoon character. Each style is further represented by a set of drawing textures, color palettes and other rendering parameters for use in generating a caricature. Thus, for a style of animation wherein the characters appear as cardboard cutouts, the drawing textures cause the caricature to be rendered in a manner reminiscent of cardboard cut-outs. For a style of animation wherein the characters are drawn using thick, bold curvy lines, with vivid primary colors, the drawing textures cause the caricature to be rendered using bold, curvy lines and the color palette specifies primary colors. For a style of animation wherein the characters are drawn using thin, rough lines, with pastel colors, the drawing textures specify thin, rough lines and the color palette specifies pastel colors. As can be appreciated, numerous sets of textures, colors and other rendering features may be defined for the various artistic styles, each selected to convey the distinctive features of the associated style. The information specifying each artistic style is initially input by an artist or other operator of the system, who specifies the particular geometric nodes, color palettes, drawing textures and the like for each style. Within item **141** of **FIG. 4**, note that the computer system need not actually store the image of the cartoon shown therein. The image of the cartoon is provided in the figure merely to help to illustrate the idea of a general artistic style.

Within step **142**, the system then adjusts the nodes of the caricature generated based upon the user input photograph with the nodes of the selected artistic style. For example, the system extracts the image corresponding to the right eye of the user caricature (item **147** of **FIG. 4**) and adjusts the image based on the nodes of the artistic style (item **145** of **FIG. 4**) to generate a more bulbous right eye (item **149** of **FIG. 4**). A variety of techniques may be employed to perform the actual adjustment operation. In one example, the system first determines, for each node within the user caricature, a new location for the node by averaging the node locations from the user caricature with those of the artistic style based upon a predetermined biasing or weight factor which biases the average either toward the node location of the user caricature or to the node location of the artistic style. For example, the blending process may be fully biased towards the artistic style by setting the new node locations for the user caricature to be equal to the node locations of the artistic style. As a result, within a particular facial zone, the adjusted caricature image will more closely conform to the artistic style, rather than to the original user image. In

another example, the biasing is weighted heavily in favor of the user caricature such that the adjusted facial feature perhaps only slightly adopts the characteristics of the artistic style. Preferably, the biasing factors are input by the artist or other operator along with the other information defining the artistic style. To this end, the artist or other operator may subjectively evaluate the degree of distinctiveness of various features within the artistic style and assign very distinctive features a high biasing level and less distinctive features a lower biasing level. In this manner, when the adjustment procedure is performed, highly distinctive features of the artistic style are evoked within the adjusted image. Depending upon the programming of the system, the user may be permitted to adjust the weight factors as well. Also, as noted above, the artistic style may provide fewer nodes per facial feature than the user caricature provides. If so, the adjustment process thus far described is modified as needed to determine new locations for each node of the caricature based on the fewer node locations of the artistic style.

Thus, following step **142**, the system has generated a new set of node locations corresponding to the pre-determined image zones. Next, at step **144**, the system automatically renders a new caricature based on the new set of node locations using the aforementioned artistic style textures, color palettes and the like to yield a final composite image (item **151** of **FIG. 4**). If the original caricature included colors, the new caricature can be rendered using the original colors modified using the color palette of the artistic style. As can be seen from **FIG. 4**, the final image retains characteristics drawn from both the initial user photograph and the selected artistic style. The final image is displayed to the user and, if satisfactory, is employed by the user perhaps as part of the aforementioned computer message or perhaps as an Avatar for use in a chat room or multi-game user computer game. If unacceptable, the user may select a different artistic style and repeat the process illustrated in **FIG. 3** or, if permitted by the system, may attempt to selectively control the rendering process to achieve a more satisfactory result. Depending upon the programming of the system, the user caricature may be automatically rendered using many different artistic styles, with thumbnail sketches of each resulting caricature simultaneously displayed so that the user may select one.

Thus, what has been described with reference to **FIG. 3** is a technique for generating a new caricature based on the original caricature but rendered in a manner consistent with a selected artistic style. With reference to **FIG. 5**, techniques for merging the original caricature with another caricature will be described. At step **240**, the system inputs a new caricature selected by the user for merging with the caricature previously generated by the system based on

the user photograph. The new caricature may be representative, for example, of a celebrity, historical figure or cartoon character. Such caricatures are preferably input into the system by an artist or other operator. The artist or other operator inputs the specific geometric nodes corresponding to the facial features within each zone of the caricature. Preferably, a relatively large number of nodes are input to permit the caricature to closely resemble the particular celebrity, historical figure or cartoon character. Alternatively, the new caricature may be another caricature generated by the user, perhaps from a different input photograph. In either case, each caricature is stored within the system in vector form using the aforementioned geometrical nodes.

Within step **242**, the system then generates new node locations based on the nodes of the user caricature and the nodes of the selected caricature. This may be performed using the same method of **FIG. 3** to average node locations from the user caricature with those of the other caricature based upon a predetermined biasing or weight factors. The system generates a final image of the merged caricature based on the new node locations for display to the user and, if satisfactory, the new caricature is employed by the user as part of the aforementioned computer message or perhaps as an Avatar for use in a chat room or multi-game user computer game. If unacceptable, the user may choose to select a different pre-stored caricature for creating a merged character and repeat the process illustrated in **FIG. 5** or, if permitted by the system, may attempt to selectively control the merging process to achieve a more satisfactory result. Depending upon the programming of the system, the user caricature may be automatically merged with many different pre-stored caricatures, with thumbnail sketches of each resulting merged caricature simultaneously displayed so that the user may select one.

Thus, what has been described with reference to **FIG. 5** is a technique for merging a caricature derived from a photograph with a pre-stored caricature. Alternatively, the general techniques of **FIG. 5** may be employed to merge two separate caricatures provided by the user. Alternatively, the system may be programmed to enable the user to select two pre-stored caricatures for merging together. The system is not restricted to merging facial caricatures together. Rather, the technique may also be applied to merging other caricatures together, such as merging the caricature of a real house with that of a cartoon house. Also, the general technique of performing merging operations, on a zone-by-zone basis, may be applied to other merging techniques as well, including those not limited to the merging of caricatures together. The techniques of **FIGS. 1 - 5** have been described with respect to flow charts. Each block within the flowcharts illustrated both a method step and an apparatus element for performing the

corresponding method step. Accordingly, **FIGS. 1 - 5** also represent an image processing system. The high-level features of the system are also represented within **FIG. 6**.

Briefly, **FIG. 6** illustrates functional components of a web site **300** performing the techniques of **FIG. 1 - 5**. The system includes an image selection unit **301** for inputting an image provided by a user via an input unit **302** or for allowing the user to select a pre-stored image from an image database **303**. The system also includes a caricature generation unit **304** for converting the input image into a caricature, perhaps for transmission via a transmission unit **306** such as a modem over the Internet **308** or other computer network. Caricature generation unit **304** converts a selected image into a caricature image using an image to geometrical node conversion unit **310**, which extracts a set of geometrical nodes from the selected image, and a caricature rendering unit **312,** which renders a caricature based on the extracted geometrical nodes. The nodes are extracted from the selected image on a zone-by-zone basis from set of predefined image zones, such as the eyes, nose and mouth. The zones are located within the image using an image zone locator unit **315**. The geometrical nodes are stored in a node storage unit **313**.

The web site also includes an artistic style conversion unit **316** which may be used to modify the caricature to adopt an artistic style selected from an artistic style database **318**. The system also includes a caricature merge unit **320** which may be used to merge a caricature generated by caricature generation unit **304** with a pre-stored caricature stored in vector-based format within node database **313**. Specific operations performed by the various components illustrated in **FIG. 6** are described above with reference to **FIGS. 1 - 5**.

The description of the exemplary embodiments is provided to enable any person skilled in the art to make or use the invention. Various modifications to the embodiments will be readily apparent and generic principles defined herein may be applied to other embodiments. Thus, the invention is not intended to be limited to the specific embodiments shown and described herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

CLAIMS

1. An interactive network web site comprising:
an image selection unit for receiving a user selection of an image; and
a caricature generation unit for automatically generating a caricature image representative of the selected image.

2. The interactive network web site of claim 1 wherein the image selection unit includes an input unit for inputting an image provided by the user.

3. The interactive network web site of claim 1 further including a selected image verification unit for determination whether the selected image meets a predetermined threshold of image integrity.

4. The interactive network web site of claim 3 wherein the input image verification unit determines whether the selected image meets a predetermined threshold by analyzing one or more of the exposure, contrast and focus of the image.

5. The interactive network web site of claim 1 wherein the image selection unit includes storage unit for storing images for selection by the user.

6. The interactive network web site of claim 1 wherein the image selected by the user is a bit-mapped image and wherein the caricature generation unit generates a vector representation of the bit-mapped input image.

7. The interactive network web site of claim 1 wherein the caricature generation unit locates a set of image zones within the selected image, separately converts portions of the selected image lying within each image zone into respective caricature image portions, and combines the caricature image portions to yield a resulting combined caricature image.

8. The interactive network web site of claim 7 further including:
an artistic style storage unit for storing information representative of a plurality of artistic styles
an artistic style selection unit for receiving a user selection of one of the artistic styles; and
an artistic style conversion unit for converting the caricature image based on the selected artistic style.

9. The interactive network web site of claim 8 wherein the information representative of an artistic style includes information defining colors and textures.

10. The interactive network web site of claim 1 further including a message generation unit for generating a message for transmission via the interactive network, for embedding the caricature image into the message, and for transmitting the message.

11. The interactive network web site of claim 10 wherein the message generation unit receives a user selection of a message format from a set of pre-stored message formats and embeds the caricature image into the selected message format.

12. The interactive network web site of claim 11 wherein the pre-stored image formats include one or more formats directed to holiday greetings, birthday greetings, and reminder messages.

13. The interactive network web site of claim 10 wherein the message generation unit inputs digitized speech provided by the user and embeds the digitized speech in the message.

14. The interactive network web site of claim 1 further including a caricature merge unit for merging the caricature image with another caricature image to create a merged caricature image.

15. The interactive network web site of claim 14 wherein the caricature merge unit locates a set of corresponding image zones within the caricature images, separately merges portions of the caricature images within each image zone into respective merged image portions, and combines the merged image portions to yield a resulting combined merged caricature image.

16. The interactive network web site of claim 1 wherein the web site is connected to the Internet.

17. A method performed by an interactive network web site comprising the steps of:
receiving a user selection of an image; and
automatically generating a caricature image representative of the selected image.

18. The method of claim 17 wherein the step of receiving a user selection of an image includes the step of inputting an image provided by the user.

19. The method of claim 17 further including the step of analyzing the selected image to determine whether the image meets a predetermined threshold of image integrity and rejecting the image if it falls below the threshold.

20. The method of claim 19 wherein the step of analyzing the input image to determine whether the image meets a predetermined threshold includes the steps of analyzing one or more of the exposure, contrast and focus of the image.

21. The method of claim 17 wherein the step of receiving a user selection of an image includes the step of displaying stored images for selection by the user.

22. The method of claim 17 wherein the image selected by the user is a bit-mapped image and wherein the step of automatically generating a caricature image is performed to generate a
vector representation of the bit-mapped input image.

23. The method of claim 17 wherein the step of automatically generating a caricature image locates a set of image zones within the selected image, separately converts portions of the input image lying within each image zone into respective caricature image portions, and combines the caricature image portions to yield a resulting combined caricature image.

24. The method of claim 17 further wherein the caricature image is a line art image.

25. The method of claim 17 further comprising the steps of:
storing information representative of a plurality of artistic styles
artistic style selection unit for receiving a user selection of one of the artistic styles; and
converting the caricature image based on the selected artistic style.

26. The method of claim 25 wherein the information representative of an artistic style includes information defining colors and textures.

27. The method of claim 17 further including the steps of generating a message for transmission via the interactive network, for embedding the caricature image into the message, and for transmitting the message.

28. The method of claim 27 wherein the step of generating a message includes the steps of receiving a user selection of a message format from a set of pre-stored message formats and embedding the caricature image into the selected message format.

29. The method of claim 28 wherein the pre-stored image formats include one or more formats directed to holiday greetings, birthday greetings, and reminder messages.

30. The method of claim 27 further including the step of inputting digitized speech provided by the user and embedding the digitized speech in the message.

31. The method of claim 17 further including the step of merging the caricature image with another caricature image to create a merged caricature image.

32. The method of claim 31 wherein the step of merging the caricature image with another caricature image locates a set of corresponding image zones within the caricature images, separately merges portions of the caricature images within each image zone into respective merged image portions, and combines the merged image portions to yield a resulting combined merged caricature image.

33. A method, performed by a computing system, for converting an input image into a computer representation of a caricature image comprising the steps of:
locating a set of image zones within the input image; and
separately converting portions of the input image lying within each image zone into individual respective caricature representations; and
combining the individual respective caricature representations to yield a combined caricature representation.

34. The method of claim 33 wherein the input image is a facial image and wherein the set of image zones are facial image zones.

35. The method of claim 33 wherein the facial image zones include the left eye, the right eye, the nose and the mouth.

36. The method of claim 33 wherein the step of locating a set of image zones within the input image includes the steps of:

associating a set of discrete image zone templates with the input image, with each discrete image zone template corresponding to a respective one of the image zones; and

converting portions of the input image corresponding to each discrete image zone template into a respective caricature image.

37. The method of claim 36 wherein the set of discrete image zone templates are constrained with respect to an image template outline and wherein the step of associating the set of image zone templates with the input image includes the steps of:

extracting the outline of the input image;

adjusting a size and location of the image template outline to match the outline of the input image while adjusting sizes and locations of the discrete image zone templates in accordance with the adjusted size and location of the image template outline; and

determining the final adjusted locations of the image zone templates with respect to the input image.

38. The method of claim 33 wherein the input image is a bit-mapped image.

39. The method of claim 38 wherein the step of separately converting portions of the input image lying within each image zone into individual respective caricature representations includes the step of, for each respective template zone, applying a corresponding predetermined bit-map to caricature conversion algorithm to the portion of the bit-map lying within the respective template zone.

40. The method of claim 39 wherein at least some of the corresponding predetermined bit-map to caricature conversion algorithms differ from one another.

41. The method of claim 40 wherein the input image is a facial image, the image zones of the facial image include the left eye, the right eye, the nose and the mouth and wherein a first conversion algorithm is applied for the left and right eye template zones, a second conversion algorithm is applied to the nose template zone and a third conversion algorithm is applied to the mouth template zone.

42. The method of claim 41 wherein the first conversion algorithm is adapted for converting a bit-mapped representation of an eye to a caricature representation of an eye, the second conversion algorithm is adapted for converting a bit-mapped representation of a nose to a caricature representation of a nose, and the third conversion algorithm is adapted for converting a bit-mapped representation of a mouth to a caricature representation of a mouth.

43. The method of claim 33 wherein the caricature image is a line art image.

44. A method, performed by a computing system, for rendering a caricature image comprising the steps of:

inputting a caricature image representation;

selecting an artistic style; and

rendering an image based on the caricature image representation while applying the selected artistic style.

45. The method of claim 44 wherein the selected artistic style includes a specification of line textures and color palettes.

46. The method of claim 45 wherein the step of rendering the image comprises the steps of:

locating a set of image zones associated with the caricature image;

identifying geometrical artistic style characteristics for use with each respective image zone;

separately modifying portions of the caricature image representation within the image zones based on the geometrical artistic style characteristics identified for use with each respective image zone to yield separately modified image zone portions;

combining the separately modified image zone portions.

47. The method of claim 44 wherein the step of separately modifying portions of the caricature image within the image zone based on the geometrical artistic style characteristics identified for use with each respective image zone includes the step of, for each image zone, identifying a set of geometric features within the image zone and then adjusting the geometric features based on a corresponding set of geometric features of the artistic style for that zone.

48. The method of claim 47 wherein different zones are assigned different weight factors and wherein the images lying within the image zones of the caricature image are adjusted based on the corresponding set of geometric features of the artistic style to a degree based on the weight factor.

49. The method of claim 48 wherein the geometric features include predetermined geometric points and geometric tangents defining vectorized caricature images.

50. The method of claim 47 wherein the images lying within the image zones of the caricature image are adjusted by averaging locations of the corresponding geometric points within the caricature image and the artistic style to yield a set of average locations of geometric features.

51. The method of claim 44 wherein the artistic style is selected from a set of pre-determined artistic styles representative of different types of art.

52. A method for combining computer representations of first and second images comprising the steps of:

locating a set of corresponding image zones within the first and second images;

separately modifying image zones of the first image based on characteristics of corresponding image zones of the second image to yield separately modified image zones; and

combining the separately modified image zones to yield a modified image.

53. The method of claim 52 wherein the first and second images are caricature images.

54. The method of claim 53 wherein the first and second caricature images are facial images and wherein the set of image zones are facial image zones.

55. The method of claim 52 wherein the step of separately modifying image zones of the first image based on characteristics of corresponding image zones of the second image includes the step of, for each image zone, identifying corresponding sets of geometric features within the first and second images and then adjusting the images lying within the image zone of the first image based on the corresponding sets of geometric features from the second image.

56. The method of claim 55 wherein different zones are assigned different weight factors and wherein the images lying within the image zones of the first image are adjusted to a degree based on the weight factor.

57. The method of claim 52 wherein the image zones contain caricature images and the sets of features include one or more of predetermined geometric points or geometric tangents within the caricature images.

58. The method of claim 55 wherein the images lying within the image zones of the first image are adjusted by averaging locations of the corresponding geometric points within the first and second facial images to yield a set of average locations of geometric features, then modifying the images lying within the image zones of the first image based on the average locations of the geometric features of the second image.

59. The method of claim 52 wherein in the first image is a bit-mapped image and the second image is a caricature image and wherein the method further includes the steps of :

extracting the outline of the bit-mapped image;

extracting the outline of the caricature image;

conforming the outline of the caricature image to that of the bit mapped image to yield a modified caricature outline; and

combining the modified caricature outline with the modified image generated by combining the separately modified image zones to yield a combined modified image.

60. The method of claim 52 wherein the first image is a bit-mapped photograph and the second image is a cartoon.

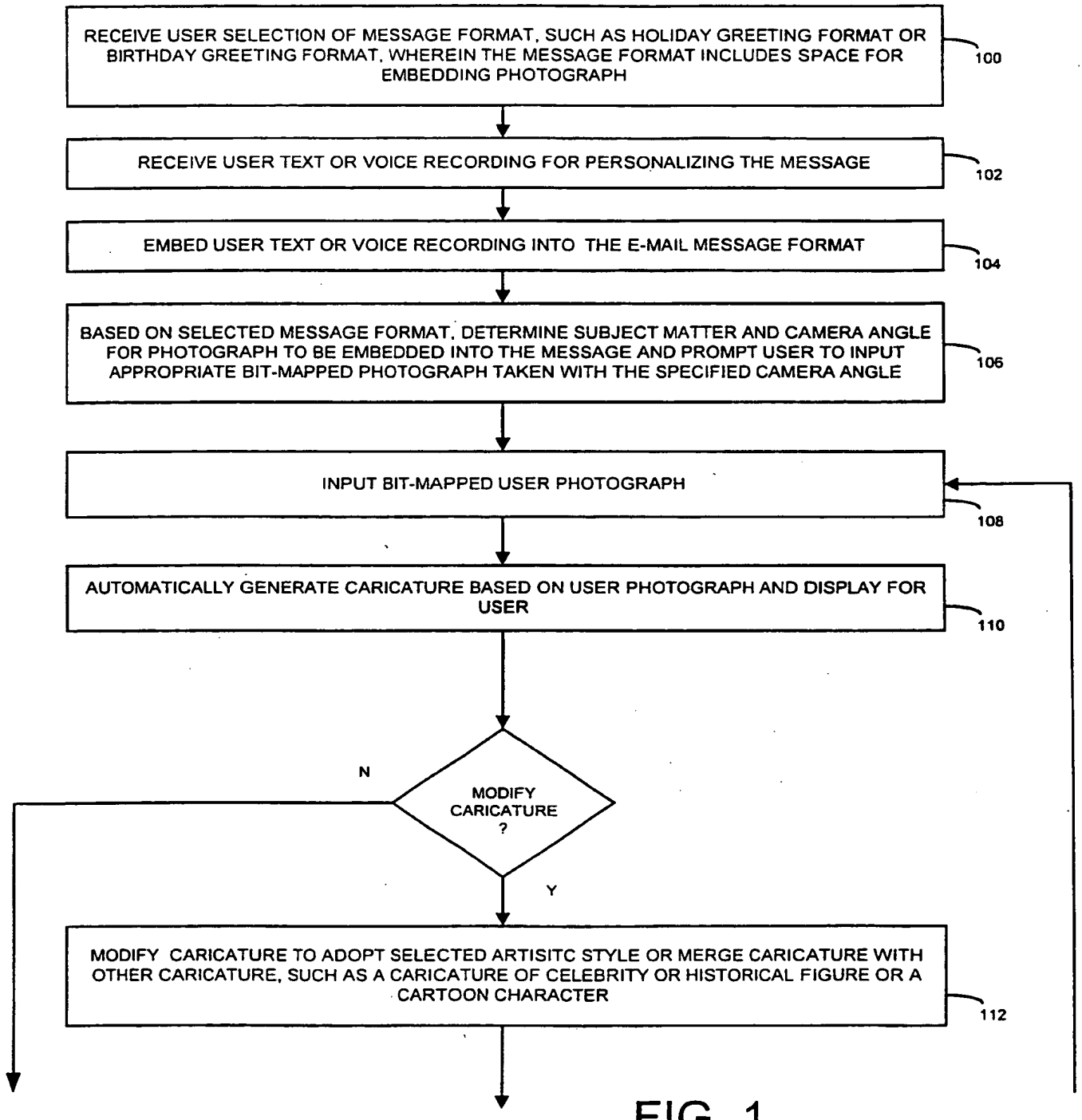

RECEIVE USER SELECTION OF MESSAGE FORMAT, SUCH AS HOLIDAY GREETING FORMAT OR BIRTHDAY GREETING FORMAT, WHEREIN THE MESSAGE FORMAT INCLUDES SPACE FOR EMBEDDING PHOTOGRAPH
100
RECEIVE USER TEXT OR VOICE RECORDING FOR PERSONALIZING THE MESSAGE
102
EMBED USER TEXT OR VOICE RECORDING INTO THE E-MAIL MESSAGE FORMAT
104
BASED ON SELECTED MESSAGE FORMAT, DETERMINE SUBJECT MATTER AND CAMERA ANGLE FOR PHOTOGRAPH TO BE EMBEDDED INTO THE MESSAGE AND PROMPT USER TO INPUT APPROPRIATE BIT-MAPPED PHOTOGRAPH TAKEN WITH THE SPECIFIED CAMERA ANGLE
106
INPUT BIT-MAPPED USER PHOTOGRAPH
108
AUTOMATICALLY GENERATE CARICATURE BASED ON USER PHOTOGRAPH AND DISPLAY FOR USER
110
MODIFY CARICATURE ?
N
Y
MODIFY CARICATURE TO ADOPT SELECTED ARTISITC STYLE OR MERGE CARICATURE WITH OTHER CARICATURE, SUCH AS A CARICATURE OF CELEBRITY OR HISTORICAL FIGURE OR A CARTOON CHARACTER
112

FIG. 1

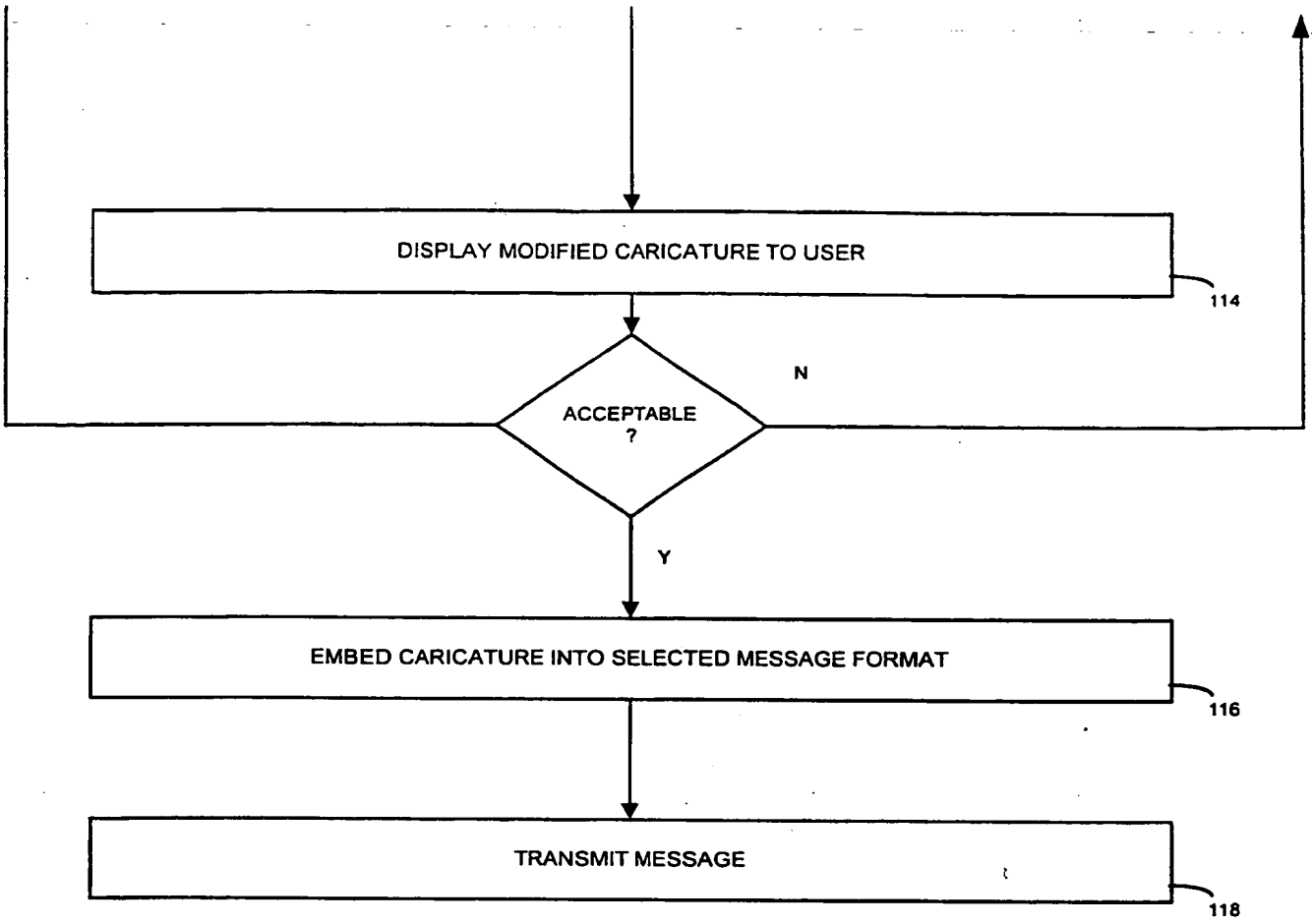

DISPLAY MODIFIED CARICATURE TO USER
114
ACCEPTABLE ?
N
Y
EMBED CARICATURE INTO SELECTED MESSAGE FORMAT
116
TRANSMIT MESSAGE
118

FIG. 1
(CONT.)

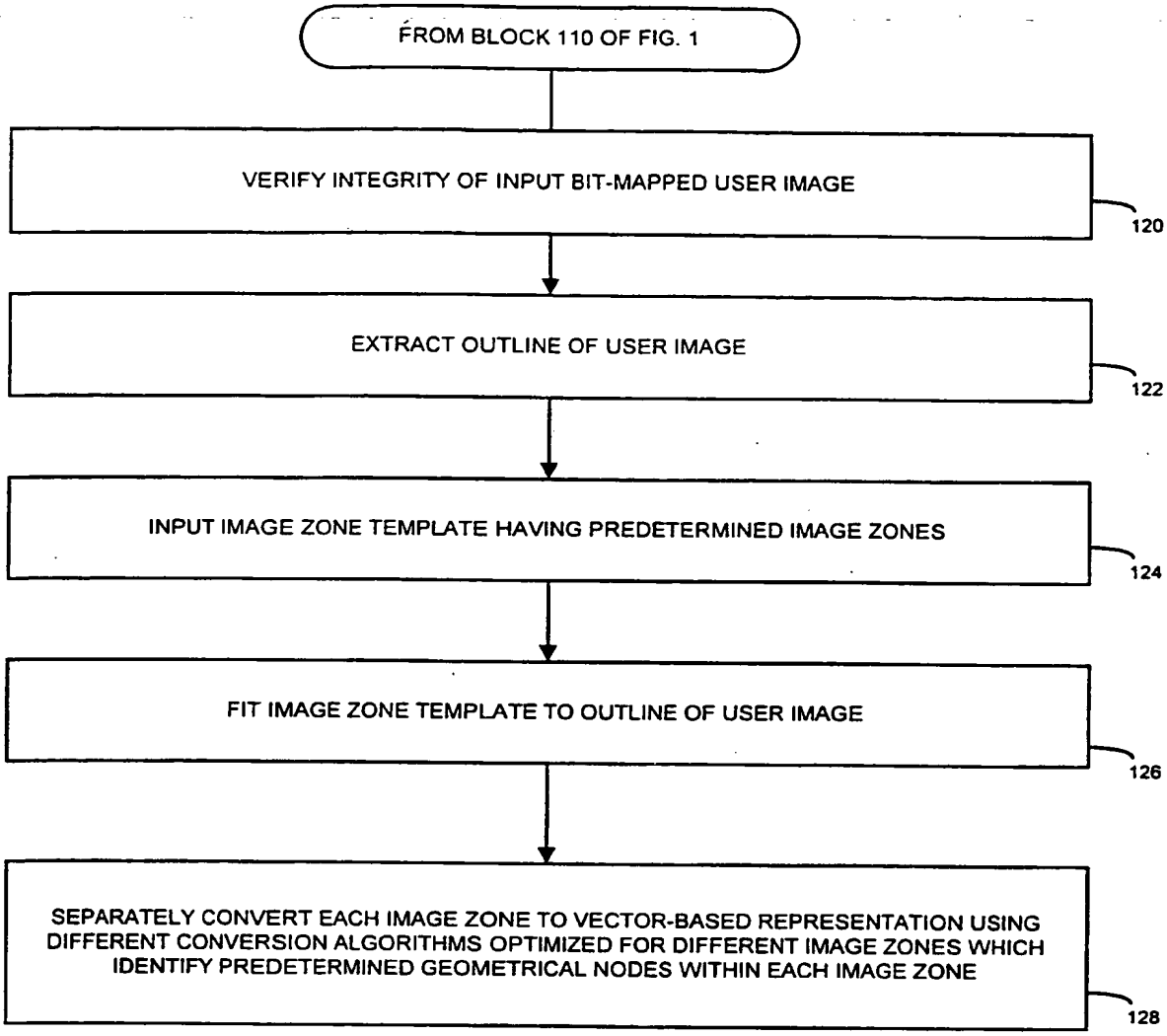

FROM BLOCK 110 OF FIG. 1
VERIFY INTEGRITY OF INPUT BIT-MAPPED USER IMAGE
120
EXTRACT OUTLINE OF USER IMAGE
122
INPUT IMAGE ZONE TEMPLATE HAVING PREDETERMINED IMAGE ZONES
124
FIT IMAGE ZONE TEMPLATE TO OUTLINE OF USER IMAGE
126
SEPARATELY CONVERT EACH IMAGE ZONE TO VECTOR-BASED REPRESENTATION USING DIFFERENT CONVERSION ALGORITHMS OPTIMIZED FOR DIFFERENT IMAGE ZONES WHICH IDENTIFY PREDETERMINED GEOMETRICAL NODES WITHIN EACH IMAGE ZONE
128

FIG. 2

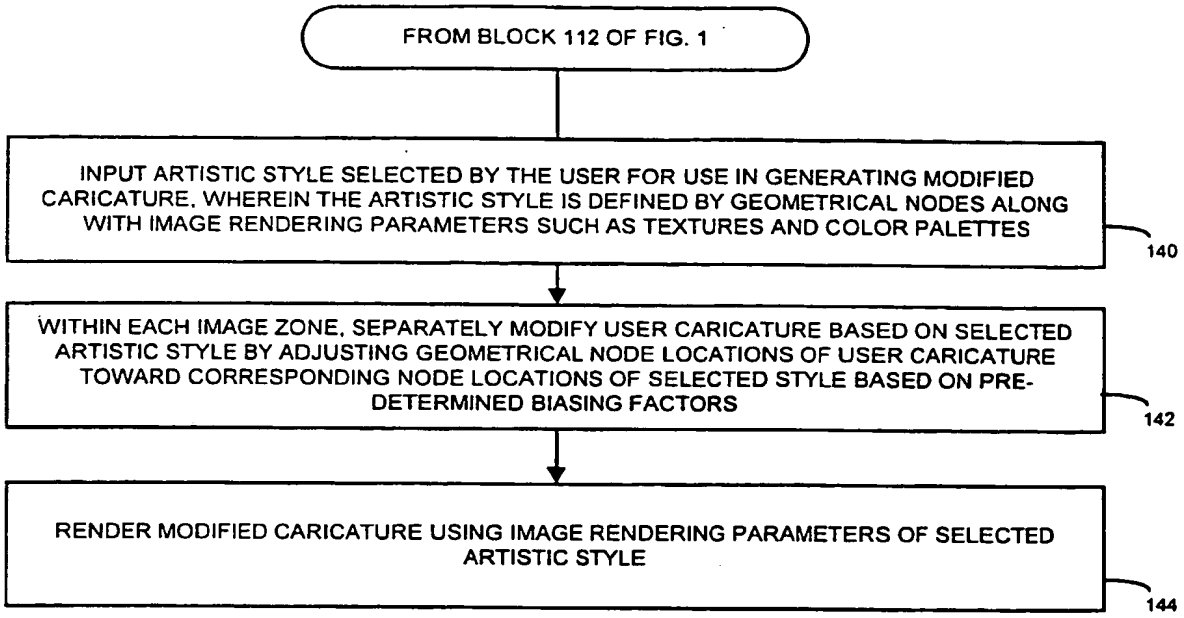

FROM BLOCK 112 OF FIG. 1
INPUT ARTISTIC STYLE SELECTED BY THE USER FOR USE IN GENERATING MODIFIED CARICATURE, WHEREIN THE ARTISTIC STYLE IS DEFINED BY GEOMETRICAL NODES ALONG WITH IMAGE RENDERING PARAMETERS SUCH AS TEXTURES AND COLOR PALETTES
140
WITHIN EACH IMAGE ZONE, SEPARATELY MODIFY USER CARICATURE BASED ON SELECTED ARTISTIC STYLE BY ADJUSTING GEOMETRICAL NODE LOCATIONS OF USER CARICATURE TOWARD CORRESPONDING NODE LOCATIONS OF SELECTED STYLE BASED ON PRE-DETERMINED BIASING FACTORS
142
RENDER MODIFIED CARICATURE USING IMAGE RENDERING PARAMETERS OF SELECTED ARTISTIC STYLE
144

FIG. 3

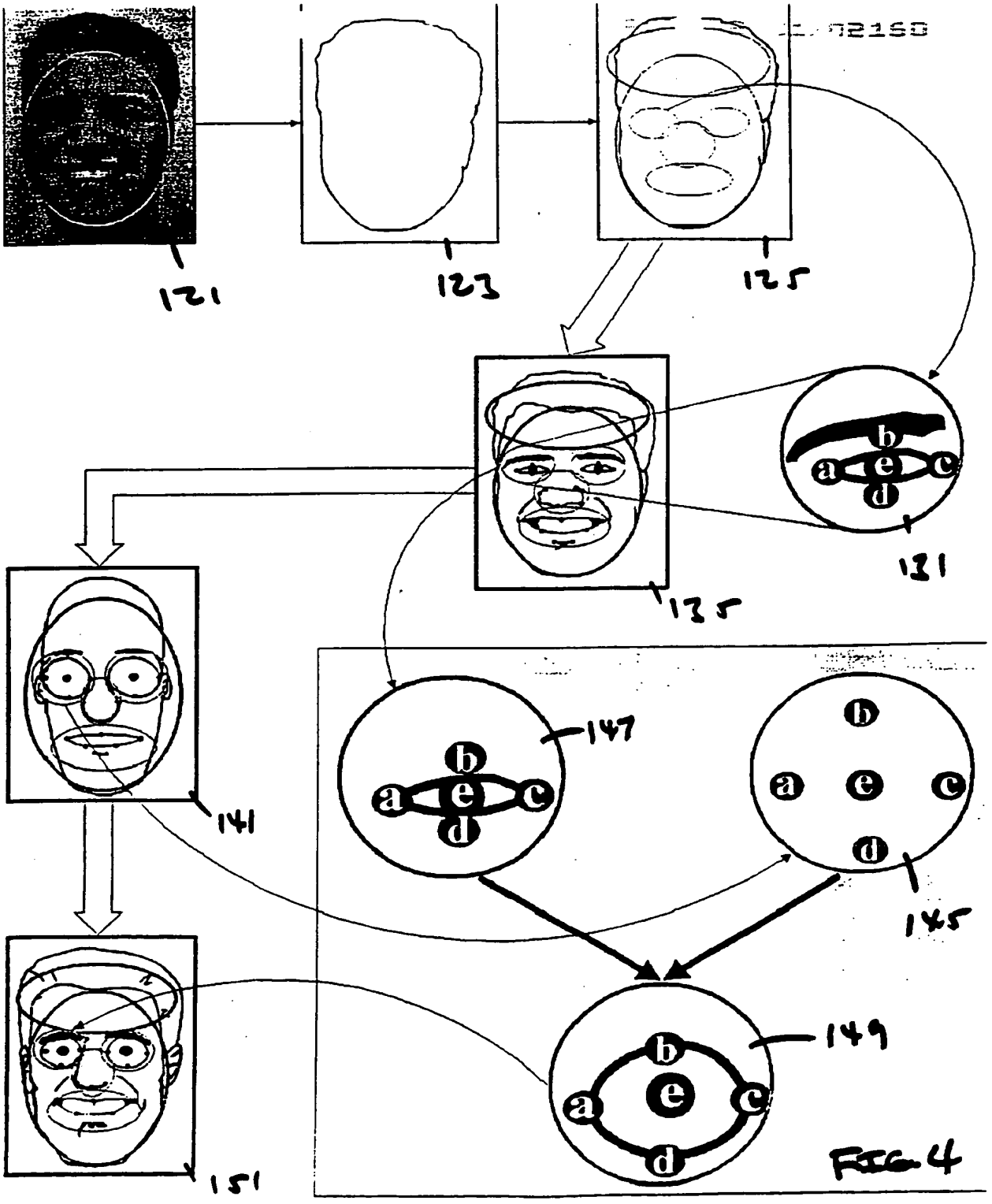


FIG. 4

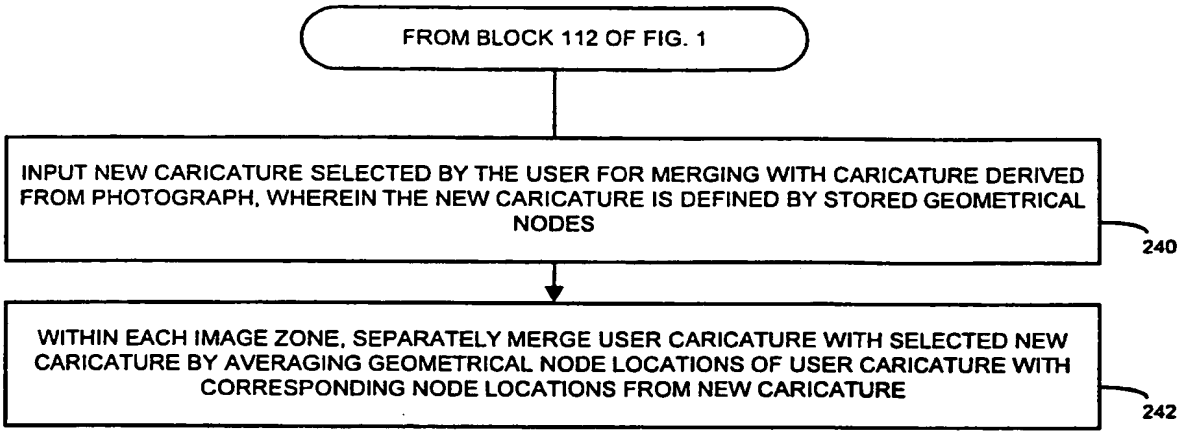

FROM BLOCK 112 OF FIG. 1
INPUT NEW CARICATURE SELECTED BY THE USER FOR MERGING WITH CARICATURE DERIVED FROM PHOTOGRAPH, WHEREIN THE NEW CARICATURE IS DEFINED BY STORED GEOMETRICAL NODES
240
WITHIN EACH IMAGE ZONE, SEPARATELY MERGE USER CARICATURE WITH SELECTED NEW CARICATURE BY AVERAGING GEOMETRICAL NODE LOCATIONS OF USER CARICATURE WITH CORRESPONDING NODE LOCATIONS FROM NEW CARICATURE
242

FIG. 5

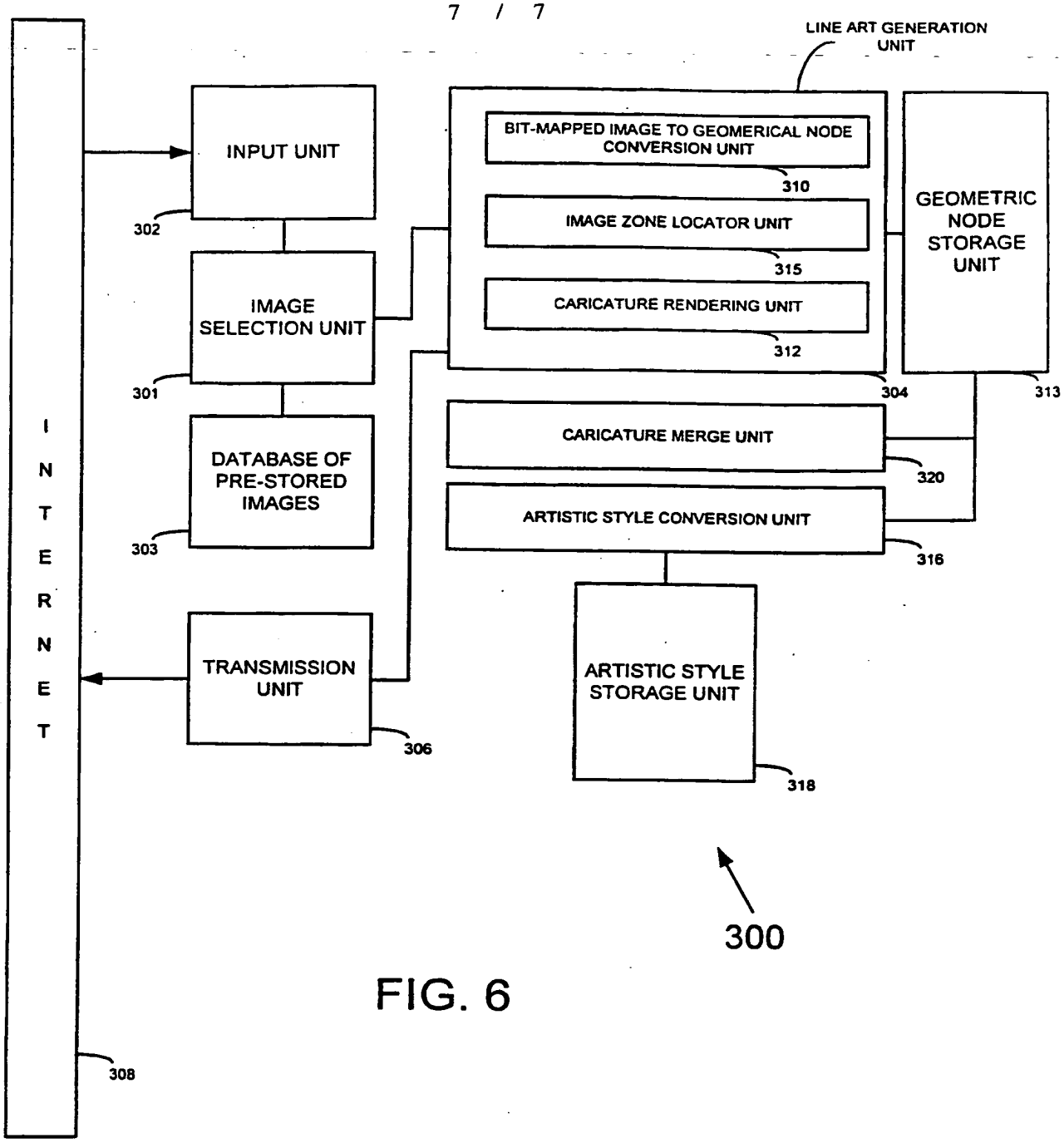

LINE ART GENERATION UNIT
INPUT UNIT
302
IMAGE SELECTION UNIT
301
DATABASE OF PRE-STORED IMAGES
303
TRANSMISSION UNIT
306
INTERNET
308
BIT-MAPPED IMAGE TO GEOMERICAL NODE CONVERSION UNIT
310
IMAGE ZONE LOCATOR UNIT
315
CARICATURE RENDERING UNIT
312
304
GEOMETRIC NODE STORAGE UNIT
313
CARICATURE MERGE UNIT
320
ARTISTIC STYLE CONVERSION UNIT
316
ARTISTIC STYLE STORAGE UNIT
318
300

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/02160

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : G06T 7/00
US CL : 345/433
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 345/433

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KONDO ET AL., From Coarse to Fine Correspondence of 3-D Facial images and its Application to 3-D Facial Caricaturing, 1997, IEEE, 3-D Digital Imaging and Modeling, 1997, pages 283-288.	1, 2, 5-7, 14, 17, 18, 22-24, 31, and 33-43
X	NISHINO ET AL., entitled Fuzzy Linguistic Facial Caricature drawing system, 1998, IEEE, Second International Conference on Knowledge-Based Intellignet Electronic Systems, April 1998, Proceedings KES '98, Volume 2, 1998, pages 15-20.	1, 2, 5, 6, 8, 9, 17, 18, 22, 24-26, 44, and 45
Y	LYONS ET AL., Avatar Creation using Automatic Face Processing, Proceedings of the sixth ACM international conference on Multimedia, ACM multimedia '98, September 13-16, 1998, pages 427-434.	15, 32, and 52-60
X — Y	KOSHIMIZU ET AL., On KANSEI Facial Image Processing For Computerized Facial Caricaturing System PICASSO, IEEE International Conference on Systems, Man, and Cybernetics, 1999, IEEE SMC '99 Conference Proceedings, Volumne 6, 1999, pages 294-299	1-7, 14, 16-24, 31, and 33-43 8-13, 15, 25-30, 32, and 44-60

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 March 2001 (07.03.2001)	18 APR 2001
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer Jeffery A. Brier Telephone No. (703) 305-3800

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/02160

Continuation of B. FIELDS SEARCHED Item 3: WEST (USPAT, Derwnt, JPO, EPO, and IBM databases), IEEE Xplore website, and ACM Digital Library website. Search terms: caricature, cartoon.